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Some Factors Influeneced by Honey Bees on Alfalfa Seed Production in South Dakota

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SOME FACTORS INFLUENCED BY HONEY BEES ON ALFALFA SEED PRODUCTION IN SOUTH DAKOTA

By

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SOME FACTORS INFLUENCED BY HONEY BEES ON ALFALFA SEED PRODUCTION IN SOUTH DAKOTA

This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree; but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

ACKNOWLEDGMENTS

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P.W.B.

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INTRODUCTION

The utilization of the honey bee, Apis mellifera L., in alfalfa seed production is an important phase in this field of agriculture. The combined efforts of the seed producer and the beekeeper must be utilized to the greatest extent to insure the maximum production of alfalfa seed.

Efforts to increase alfalfa seed production are being intensified due to the rising demand for this legume in modern agriculture. Hughes, et al. (1953) stated that alfalfa, Medicago sativa (L.), is produced throughout the world. They also indicated a steady increase in production since 1900. Soil structure and fertility are greatly aided by the planting of alfalfa on poor, run-down soils. It builds up the nitrogen content of the soil, lessening the need for continuous application of fertilizers. Organic matter from alfalfa greatly reduces soil erosion due to wind and water. Its rapid growth provides a good source of legume hay plus the opportunity for a seed crop the same year.

Factors governing the amount of seed produced are many and variable. A constant check must be kept to properly manage both the beneficial and the harmful factors which affect seed production. Weather, a very important item, is controllable to the extent of basing proper management practices on the forecasts. Its sudden changes can alter the program in a very short time. Plant diseases, insect populations, soil conditions, cultural and management practices all present problems to both the seed producer and the beekeeper.

It is very important to insure proper management prior to the pollination period. This insures a healthy, vigorous stand which can support the greatest amount of blossoms. A high percentage of the blossoms must be pollinated in a very short time to give the best seed yields. Proper weather conditions with the presence of large numbers of pollinating insects are required for transferring pollen at the rapid rate required.

At this point, the honey bee becomes a very beneficial pollinating insect. It is one of the insects which man has learned to control to make it produce desired results under different environmental conditions. Although individual honey bees are known to be less efficient pollinators of alfalfa than certain native bees, the ability to quickly place large numbers in an alfalfa field has been shown to effectively increase the seed set.

Injurious insect control need not endanger the honey bees. The application of insecticides can be put on alfalfa prior to introducing the bees. When applied before the plants bloom, even long-residue insecticides can be used with good results since the bees contact only the open florets. These organic insecticides can cause a high mortality to injurious insects, yet, used with proper precautions, they do not damage the pollinating force.

This thesis attempts to answer some of the questions as to how honey bees improve alfalfa seed yields. The major objectives of this study were:

1. To determine the distance from the apiary which produced the greatest seed yield.
2. To determine the direction (relating to north, east, south or west) from the apiary which produced the greatest seed yield.

3. To determine the proportion of nectar collecting honey bees working alfalfa that also carry alfalfa pollen.

These studies were conducted in an alfalfa field near Clark, South Dakota.

REVIEW OF LITERATURE

Experimental work on alfalfa is not a recent development. For the past several years tests have been conducted on this crop to benefit the growing needs in agriculture.

Alfalfa is world wide in distribution according to Hughes et al. (1953). They indicated a steady increase in alfalfa production from 1900 to 1953 with a continual increase following this date. They stated four main requirements for a good alfalfa seed crop which are: (1) normal growth of an adapted variety, (2) the presence of pollinating insects, (3) the absence of harmful insects, and (4) bright sunny weather during bloom and harvest. Their work on the pollination aspect showed that insects are necessary for tripping alfalfa.

Moisture conditions studied by Aicher (1917) showed that excessive moisture reduces germination of the pollen grains and causes sterile blossoms. A slight lack of moisture caused a dwarfed plant condition but produced a good heavy seed. Too little moisture caused the flowers and leaves to shatter producing a defoliated appearance. Lovell (1924) discussed the climatic factors affecting alfalfa seed production. He stated the climate is the limiting factor in seed production and current weather is the major factor affecting any yield. Excessive rainfall causes the plants to grow too rank and tall for good seed production. It also decreases the amount of pollen and nectar and reduces honey production. Granfield et al. (1952) stated too much rainfall causes excessive growth, the pollen doesn't germinate, the flowers are less fertile, and there is limited activity of pollinating insects.

Pammel (1930a) explained the meaning of pollination and fertilization. He said "pollination is the conveying of pollen from stamen to stigma; the term fertilization was formerly used in this way, but fertilization takes place only after the pollen reaches the stigma; it is the impregnation of a special cell in the embryo sac of the ovule, a complicated process."

Various studies have been conducted pertaining to the method which a honey bee works on an alfalfa plant. Lounsberry (1930) reported that honey bees are more likely to work the higher flowers of a plant. They have a tendency to stay out of the area not well exposed to light, as in shaded areas and dark ravines. The bee also uses its weight and the strength of its legs to get nectar from flowers. This exerted force acts as a leverage and may cause some alfalfa plants to trip. Pammel (1930b) stated that the violet flowers are fired off by two triggers at the basal processes of the wings and keel. He also said the unexploded flowers do not set seed. Vansel et al. (1946) reported that alfalfa benefits from cross pollination and bees are the chief agent of pollen transportation. The alfalfa plant is well adapted for pollination by bees. The bee fits into the structure of the plant by straddling the keel and extending its proboscis into the throat of the flower where the tripping mechanism is located. At the time of tripping, the bee's head is caught between the standard petal and the tip of the sexual column. When the flower is tripped, small pollen granules become entangled among the hairs of the bee's head in about the spot where the stigma of the next flower tripped will strike. He noted that there was a marked contrast of seed production between plots worked by bees and plots kept free of bees. Plots with bees produced heavy seed yields while others were lacking in seed production. This was indicated by the stripped racemes on the bee-free plots resulting in no seed production. Any tripping occurred during the hours the bees were working in the field. Franklin (1951) noted nectar gathering bees usually visited all the flowers on one raceme before moving to the next raceme. He reported that honey bees frequently tripped alfalfa flowers accidentally by direct contact. The parts of the body causing this action were the prothoracic and metathoracic legs and the mouth parts. His studies further related that a bee may trip consecutive flowers and then not trip any more for some time and then again trip two or three more in a row. He also noted a decreasing number of bumblebees in certain geographical areas thus indicating that little pollination was available from native bees.

Distance and weather conditions control the activity of the honey bee, thereby affecting the seed yield. Park (1923) estimated a honey bee flew between 13 and 15 miles per hour in calm air. Eckert (1933) reported that honey bees produced colony gains when the hives were located as far as seven miles away from crops in an arid region of Wyoming. Colonies as close as two miles gained as much as those located directly in the field. Grout (1949) indicated honey bees flew longer going out than returning to the hive because they did some scouting on the way out. Considering weather, honey flow and other conditions, bees averaged approximately ten trips per day in the field. Grout gave three general rules for the use of honey bees in pollination, which were: (1) the more bees the better, (2) the use of populous colonies heavy in brood rearing, and (3) the placement of colonies as close as possible to the crop requiring pollination. He also indicated a formula for training bees to work crops which they normally would not visit. In the case of crops which require insect pollination, it would give very beneficial results. Granfield et al. (1952) stated that one average-sized colony of honey bees per acre will furnish enough field bees to make the population one bee per square yard. This number of honey bees can trip enough flowers to produce 120 pounds of seed per acre and gather enough nectar to produce 53 pounds of surplus honey. His diagram of the placement of bees in the field showed them spread out and not congested in one location. According to Ribbands (1952), results of experiments showed that increases in the foraging distances were consistantly associated with a decrease in colony gain. Colony gains decreased correspondingly on days when there was an occurrence of low temperatures, little sunshine, or high winds. His work emphasized the great effect that slight differences in weather and the apiary position have on the use of bees in pollination. Vansell (1951) had reported earlier that the dry climate of the West was very favorable for the use of honey bees as pollinators of alfalfa. Ribbands (1953) reported that foragers generally return to forage in the same field area and do not roam at random. He also stated that nectar gathering bees require more flowers than pollen collecting bees.

According to a recommendation distributed by Lofgren (1953), certain suggested procedures were developed for the practice of using honey bees for alfalfa pollination in South Dakota. Recommendations for the beekeeper were: (1) to furnish a minimum of two disease free colonies per acre with the colonies having a minimum of 1,000 square inches of brood with enough adult bees to cover the brood, (2) to place the bees in the field when it is approximately 1/8 in bloom, (3) to distribute bees in the field to insure adequate uniform coverage, and (4) to leave the bees in the field during the seed setting period. Rules for the seed grower were: (1) to provide thrifty stands of alfalfa producing maximum bloom, (2) to control harmful insects as recommended and to give the beekeeper 48 hours notice in advance of spraying, (3) to handle alfalfa and other sources of pollen so as to reduce the surrounding area competition for bees as much as possible, and (4) to harvest the seed crop as recommended and approved.

Hixson (1955) found that all species of wild bees were cyclic and therefore might be present in large numbers one year and relatively scarce the next year. Parasites were partly responsible for these fluctuations. His work on weather indicated overcast and cloudy conditions generally stopped working bees. Wind velocities below ten miles per hour produced little effect on bees working alfalfa. Some activity continued at velocities up to 25 miles per hour.

Levin et al. (1957) reported on work relating to the effect of previous locations of honey bees on alfalfa foraging. Bees having no previous experience with alfalfa tended to collect a higher amount of alfalfa pollen than bees which were present in alfalfa all the time.

Studies were conducted on the amount of seed produced at various distances from the hive. Similar effects were noted in each instance. Vansell (1951) reported a test on alfalfa at Ryer Island, California in 1947. A heavy seed set was obtained from plants within 100 yards of the colonies. These yields were 30 per cent greater than from plants 1,000 feet further away. MacVicar et al. (1952) reported that the best results on red clover seed production were obtained 500 yards out from the colonies. Their test was conducted using 68 colonies of bees on the south side of the field. Their 200 yard distance produced poor results due to a poor stand. As the distance increased from the 500 yard point, seed yields got comparatively smaller. Braun et al. (1953) ran a test on red clover using two colonies per acre. Their results showed the working of bees decreased as the distance from the colonies increased. Similar results were obtained from the seed yield with the highest level occurring closer to the colonies. Walstrom (1955) reported on honey bees placed in various locations in red clover fields. The seed yield fell off with increasing distance from the colonies. The highest seed yields occurred within 400 feet of the colonies.

Recently work with alfalfa has established the fact that nectar collecting bees are also carriers of pollen. In the identification of alfalfa pollen, Hoffman (1930) provided illustrations and descriptions to aid the worker in identifying the pollen present. Hodges (1952) work included an excellent color chart to aid in pollen identification. Levin (1955) reported on results of studies at Logan, Utah in 1947. He found that most honey bees working in alfalfa fields had small accumulations of alfalfa pollen on the proboscis fossae, or the underside of the neck region. He also stated that checks of nectar collecting bees in Canada showed 100 per cent to be carrying alfalfa pollen on the ventral posterior area of the head. Vansell (1955) also reported honey bees which were collecting alfalfa pollen in Arizona during August, 1954 all showed the presence of having pollen located on the ventral posterior portion of the head. Additional observations were made on nectar colsecticide, when properly applied, produced a very high toxicity to the bees working alfalfa. He also found in his results that sprays were considerably more toxic than dusts when applied to bees working in the field. Lofgren (1957) recommended the use of DDT and toxaphene on certain pests for legume seed crops. He also stated alfalfa in bloom should not be sprayed when bees are active. He recommended the application of toxaphene between 7:00 p.m. and 7:00 a.m. if alfalfa in bloom must be sprayed.

lecting bees in July, 1954 at Davis, California. He concluded that every honey bee collecting alfalfa nectar trips some flowers and noted that the bee was unable to remove the pollen mass. This pollen was found on the ventral posterior portion of the head. He indicated bees carried pollen on the corbicula as well as the head.

Lofgren (1956) listed some factors affecting alfalfa seed production: soil fertility, moisture, temperature, pollination, proper harvesting methods, plant diseases and insect pests. He also listed the principal destructive insects in alfalfa seed fields as being grasshoppers, crickets, plant bugs (lygus, alfalfa, rapid), leaf hoppers, aphids, alfalfa weevil, flea beetles, chalcids and blister beetles.

Heald (1943) described a plant disease called Common Leaf Spot, _Pseudopeziza medicaginis_ (Lib.). This disease occurs during cool, wet springs. It causes death of the stems and results in serious defoliation. At present, the only control is early cutting.

For the control of injurious insects, the crucial time for pest control is during the bud stage, from the first time the buds are visible until one week before bloom. This information was reported by Klostermeyer (1954).

Medler _et al._ (1957) stated that a mixture of insecticides was more effective than one insecticide used alone in the control of injurious insects. DDT had a variable range of toxicity to honey bees depending on time, method, atmospheric condition, and weather according to Anderson _et al._ (1952). Toxaphene also produced favorable results to low toxicity of bees in the field. A report by Weaver (1952) indicated DDT and toxaphene showed little repellency to the bees and neither insecticide, when properly applied, produced a very high toxicity to the bees working alfalfa. He also found in his results that sprays were considerably more toxic than dusts when applied to bees working in the field. Lofgren (1957) recommended the use of DDT and toxaphene on certain pests for legume seed crops. He also stated alfalfa in bloom should not be sprayed when bees are active. He recommended the application of toxaphene between 7:00 p.m. and 7:00 a.m. if alfalfa in bloom must be sprayed.

METHODS AND PROCEDURES

According to the government survey established in the Register of Deeds office at the Clark County Courthouse, Clark, South Dakota, this project was conducted primarily on the Charles Blackman farm on the Southwest Quarter (SW$\frac{1}{4}$) of Section Fourteen (14), Township One-Hundred Sixteen (116) North, Range Fifty-Seven (57), West of the 5th P.M. in Clark County, South Dakota, and contained 160 acres, more or less, in Day Township. The field work of this problem was carried out from approximately June 1, 1957 to and including October 31, 1957. Grimm alfalfa was planted in 1956 on approximately 125 acres of this quarter with the remaining acreage consisting of a slough located on the north side. This slough provided a good source of water for the honey bees.

The first growth of alfalfa was mowed from June 10 to June 15 with an International tractor and power-driven mower. The cut foliage was left on the field to build up organic matter content in the soil and help hold moisture. Under normal conditions, the length of cutting time in this field could have been shortened. The delay in cutting resulted because of intermittent rain showers as shown in table 1.

After this first cutting, sweepings for injurious and beneficial insect populations were taken. The first sweeping was taken June 20 with the remaining sweepings being taken once a week to and including August 29. All sweepings were obtained on the fifth day of each week with two exceptions being July 3 and July 24. Sweepings were taken with a standard 15 inch net at five areas in the field. The five areas were the middle, northeast, southeast, southwest, and northwest parts of the field.

Table 1. The maximum and minimum temperatures in degrees Fahrenheit and precipitation in inches for June, July, and August, 1957 at Clark, South Dakota as recorded by the United States Department of Commerce Weather Bureau.

Day of Week	June			July			August		
	Temperature		Precip.	Temperature		Precip.	Temperature		Precip.
	Max.	Min.		Max.	Min.		Max.	Min.	
1	72	43		85	64	.09	100	67	
2	78	49		88	62	.09	93	69	
3	79	49		85	62	.49	78	58	Trace
4	84	61		80	57	.52	76	56	
5	85	57		85	54		81	47	
6	75	55	.41	90	57		91	63	
7	65	52	.04	87	73		91	71	Trace
8	67	48		85	61	Trace	95	64	
9	73	58	.04	87	57		87	65	Trace
10	70	55		90	64		91	55	
11	73	48	.49	94	68		92	58	
12	75	46		94	67		94	64	
13	79	60	.04	90	63		88	65	1.18
14	69	53	.21	88	61		93	57	
15	68	49	.06	88	68	Trace	86	56	.08
16	66	54	.39	92	67		81	56	
17	75	61	.10	95	67		80	60	.01
18	72	47		98	73		77	55	Trace
19	83	52		84	65	.12	81	48	.11
20	85	52	.42	81	61		81	61	Trace
21	79	62	.33	82	64		82	60	
22	67	52	.12	87	56		77	61	Trace
23	66	50		91	59		73	59	.27
24	77	43		81	63	.17	78	47	
25	74	55	.11	83	64	.03	90	59	
26	76	46		87	56		78	49	.13
27	76	54	.04	90	65		57	50	.68
28	79	52		95	68		62	54	.05
29	85	55		95	66		73	57	.13
30	85	59		96	68	Trace	77	60	.80
31				96	62				
Average	75.2	52.2		88.7	63.3		83.0	58.3	
Total			2.30			1.51			3.44

The insects were killed with Cyanogas and brought into the laboratory at South Dakota State College for identification and population counts.

A general survey of other food sources, other apiaries, and water was taken to determine outside influences which would affect the results of this project. Figure 1 shows the approximate location of this survey in relation to the project. The approximate normal range for bees is two to three miles, therefore, no greater observation was deemed necessary. Only those plants offering major competition during alfalfa bloom were used in this work. Observations were conducted from the road so the actual size and location of each field was not drawn to scale (figure 1).

Around July 11, a yellow color began occurring on the lower alfalfa leaves. This condition continued until the lower leaves and stems had a very serious blight damage.

Injurious insects were controlled by the application of a dust mixture containing 20 per cent DDT and 20 per cent toxaphene at the rate of six pounds of dust per acre. The plants were in the pre-bud stage at this time. The machine used in this dusting operation was a C. M. Duster manufactured by Chemical Machines Ltd., Winnipeg, Manitoba, Canada (figures 2 and 3).

A 4 x 4 x 4 foot screen cage illustrated in figure 4 was set in the field after dusting to determine the seed yield from an area void of insects. Figure 5 shows the position of the cage located approximately 120 feet south and 30 feet west of the bees. Not too much emphasis was placed on this particular phase because only one cage was obtainable. To get a more accurate indication, more cages would have been desirable.

Twelve colonies of honey bees were placed on this alfalfa field

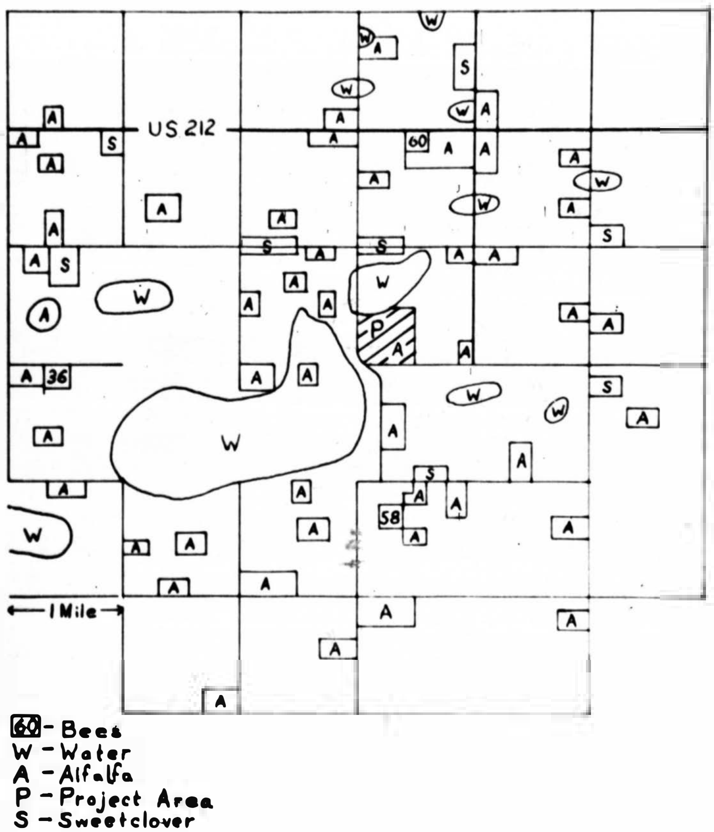

Figure 1. A sketch showing the general survey of other food sources, other apiaries, and water in relation to the project area.

Figure 2. The C. M. Duster, with booms detached, which was used for applying the insecticide.

Figure 3. The C. M. Duster in operation.

Figure 4. The 4 x 4 x 4 feet screen cage used to keep one area free of insects.

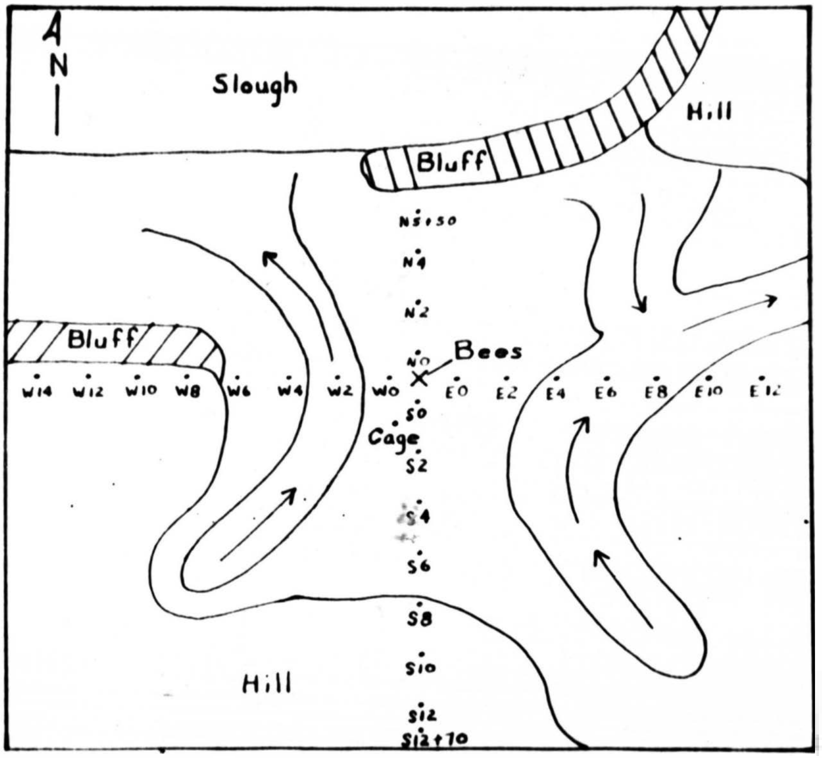

Figure 5. A sketch of the alfalfa field showing locations of honey bee colonies, the cage, stations and terrain features. Stations are located every 200 feet, an example being E2, which is 200 feet east of the bee colonies.

as shown in figure 6 by beekeeper, Frank Cook, of Clark, South Dakota. The approximate location of the colonies is illustrated in figure 5. This number of colonies fell short of the expected number (60) which were to be put on the field. The bees were placed on the field when the alfalfa was approximately 1/2 to 3/4 in bloom. One week later (August 1), the field was approximately full bloom. A more desirable time would have been when the field was about 1/8 in bloom. Both the number of colonies and time of placement were inadequate according to the recommended procedures by Lofgren (1953).

Samples of nectar collecting honey bees working alfalfa were taken in the field and later studied in the laboratory. This study was made to determine the presence, if any, of sizeable quantities of alfalfa pollen on the body of the bee. The anatomical structure studied which was found to hold accumulated alfalfa pollen on the nectar collecting honey bee was the proboscis fossae as shown in figures 7 and 8. Microscopic studies to verify the identity of the pollen were conducted in the laboratory at South Dakota State College with the aid of diagrams by Hoffman (1930) and color charts by Hodges (1952). In this procedure, pollen grains were mounted in a honey media on a microscope slide and studied at 300 magnification. Due to the low number of honey bees in this field, additional studies were carried out at other college projects to help substantiate evidence on this experiment. A statistical analysis using the sampling study was run on these bees to determine the significance of the different areas. Figures 9 and 10 illustrates the position where pollen is transported by an alfalfa pollen collecting honey bee.

Figure 6. A view of the 12 colonies of honey bees in the alfalfa field on the Charles Blackman farm.

Figure 7. An enlarged ventral view of the honey bee showing the proboscis fossae free of alfalfa pollen.

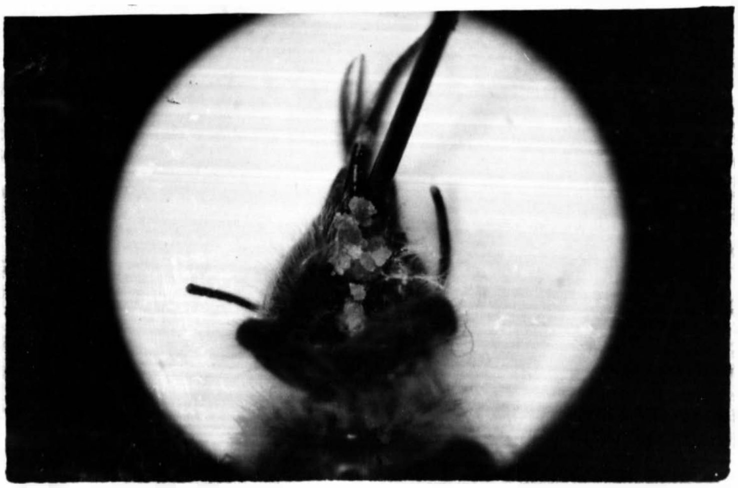

Figure 8. An enlarged ventral view of the honey bee showing the proboscis fossae filled with alfalfa pollen.

Figure 9. An enlarged view of a honey bee without alfalfa pollen in the corbicula.

Figure 10. An enlarged view of a pollen collecting honey bee containing pollen in the corbicula.

Five yard-square samples of alfalfa were cut for seed at each station (figure 5). These stations were at 200 foot intervals running in four directions (north, east, south and west) from the colonies to the edge of the field. Each direction of sampling was started on the appropriate side of the colonies, therefore, giving four zero stations. The five yard square samples were taken at one yard intervals perpendicular to the line of direction from the colonies. After being cut with a hand scythe, these samples were placed in paper bags and taken to the Entomology-Zoology storehouse at South Dakota State College where they were air-dried.

Alfalfa stem counts were taken per square yard to determine plant density at each station. These counts, limited to the first sample cut at each station, were made the same time the samples were cut.

Samples of the top six inches of soil were taken at each station and sent into South Dakota State College to be analyzed. Attempts were made here to discover any variation in the soil which might affect the seed yield.

After the samples of alfalfa had dried, they were run through a Montgomery Ward Hammermill, Model WB6A with a 1/4-inch screen (figure 11). The samples were then run through an A. T. Ferrell Grain Seed and Bean Cleaner with a 1/12- and 1/19-inch screen (figure 12). The seed was further cleaned by hand to remove the remaining foreign material.

The seed samples were then weighed to the nearest 1/1000 of a gram. To get comparisons of seed yield per acre, the grams per square yard were converted to pounds per acre by multiplying by the conversion factor 10.67.

Figure 11. The Montgomery Ward Hammermill used in threshing alfalfa.

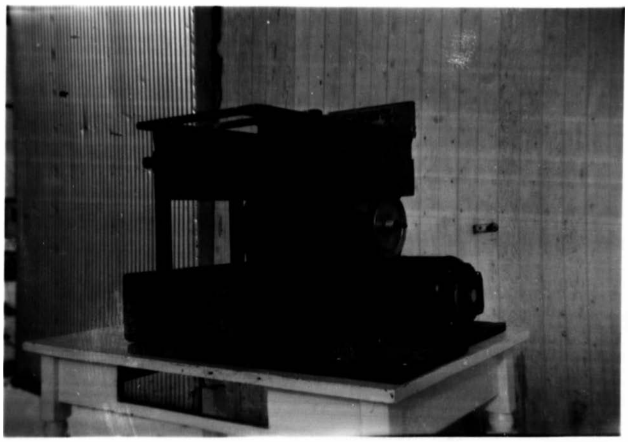

Figure 12. The A. T. Ferrell Grain Seed and Bean Cleaner used in cleaning the alfalfa seed samples.

Weather conditions pertaining to this project were obtained from the United States Department of Commerce Weather Bureau; Observer, Henry Desnoyer; Station, Clark, South Dakota. Table 1 shows this data which is for precipitation and the daily maximum and minimum temperatures.

RESULTS AND DISCUSSION

Unfavorable conditions and factors resulted in a low seed yield in this experiment. The County Agent for Clark County indicated this was an unfavorable year for alfalfa seed production and similar results were obtained in all alfalfa seed programs throughout the area.

The foliage from the first growth was left on the field for the purpose of building up the organic matter content of the soil and also to keep the top soil from drying out. Favorable growing conditions in the spring created a large amount of foliage which greatly aided these two effects. During the month of July and part of August, there was very little rainfall as indicated in table 1. Occasional observations made during this period indicated the alfalfa field had more surface moisture than other surrounding fields which lacked this protective covering. Along with these good effects, this covering was harboring certain insects. The insects used it as a refuge from the time it was cut until the new growth appeared. As a result, insect populations continued on a normal trend.

A yellowing of the leaves occurred around the first part of July which was probably Common Leaf Spot, Pseudopeziza medicaginis (Lib.). Dark brown or black spots occurred on the stems and leaves. Later symptoms caused the death of stems and defoliation of the lower leaves. Early cutting is the recommended control. The cool wet months of April, May and June favored the development of this disease. The presence of this disease reduced the vitality of the plants and made them more susceptible to insect damage and other diseases.

Results from sweeping the field showed that the lygus bug (tarnished plant bug), Lygus oblineatus (Say); rapid plant bug, Adelphocoris rapidus (Say); alfalfa plant bug, Adelphocoris lineolatus (Goeze); potato leaf hopper, Empoasca fabae (Harris); various grasshoppers, family Locustidae; pea aphid, Macrosiphum pisi (Harris); blister beetle, Epicauta pennsylvanica (DeG.); a snout beetle, Sitona scissifrons (L.); and various leaf hoppers, family Cicadellidae were the important injurious insects present. Beneficial insects found in considerable numbers were the nabid, Nabis ferus (Linn.) and lady bird beetle, Hippodamia convergens (Guer.). Their numbers and population trends before and after dusting are indicated in figures 13, 14, 15, and 16. The application of the dust mixture containing 20 per cent DDT and 20 per cent toxaphene showed favorable results in the control of the injurious insects. The ability of the dust to cover the undersides of leaves as well as to penetrate the first cutting residue on the ground produced a high mortality rate on the harmful insects. Pea aphids were increasing at a rapid rate prior to the dusting operation but were barely evident after dusting. The lygus bug and grasshopper presented early population trends which were efficiently controlled by the insecticide. Grasshoppers in the surrounding community were the insects causing most damage. The grasshopper, lygus bug and alfalfa plant bug increased in numbers the early part of August. The population increase of the nabid occurred at the same time indicating a possible aid in controlling these injurious insects. Sweepings after August 15 showed the population had decreased. A factor possibly affecting this could have been the increase of a rainy period (table 1).

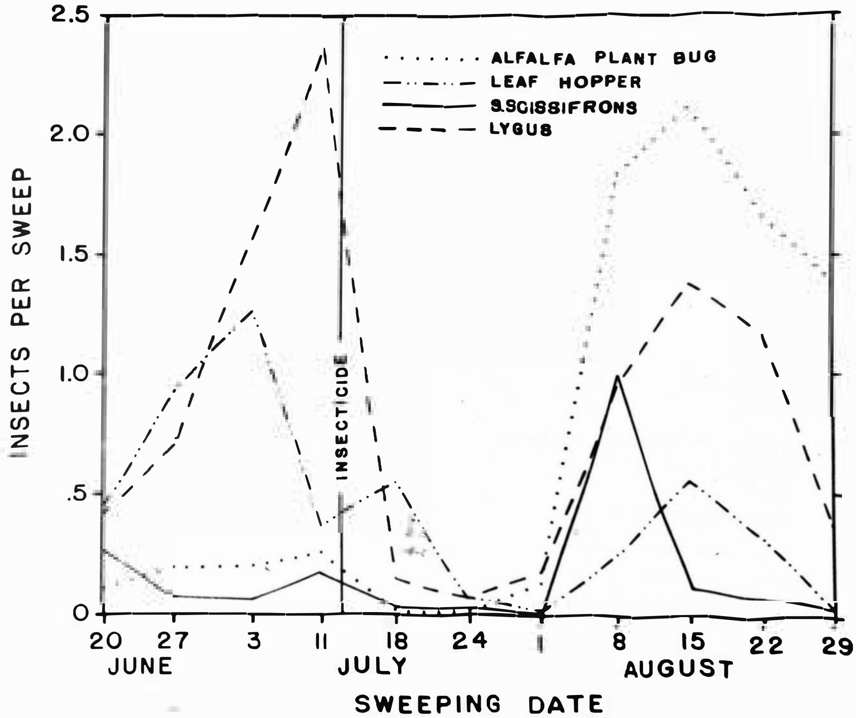

Figure 13. Population levels of the alfalfa plant bug, leaf hopper, S. scissifrons and lygus and the effects of the insecticidal application applied July 13, 1957.

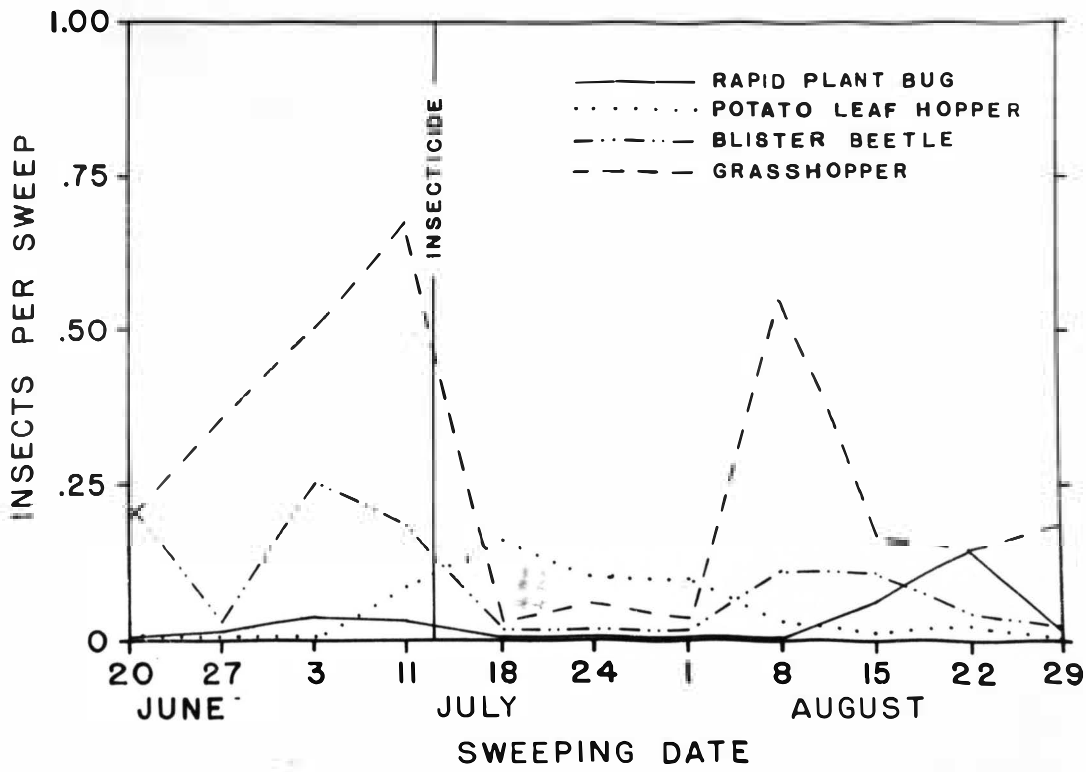

Figure 14. Population levels of the rapid plant bug, potato leaf hopper, blister beetle and grasshopper and the effects of the insecticidal application applied July 13, 1957.

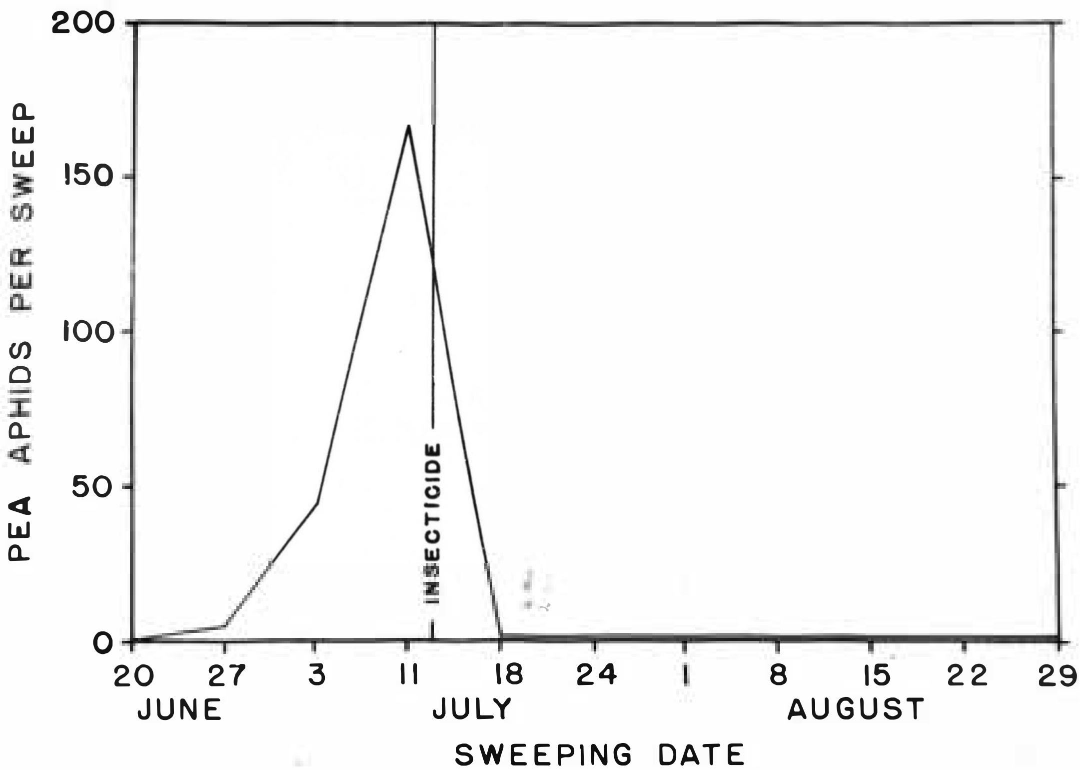

Figure 15. Population levels of the pea aphid and the effects of insecticidal application applied July 13, 1957.

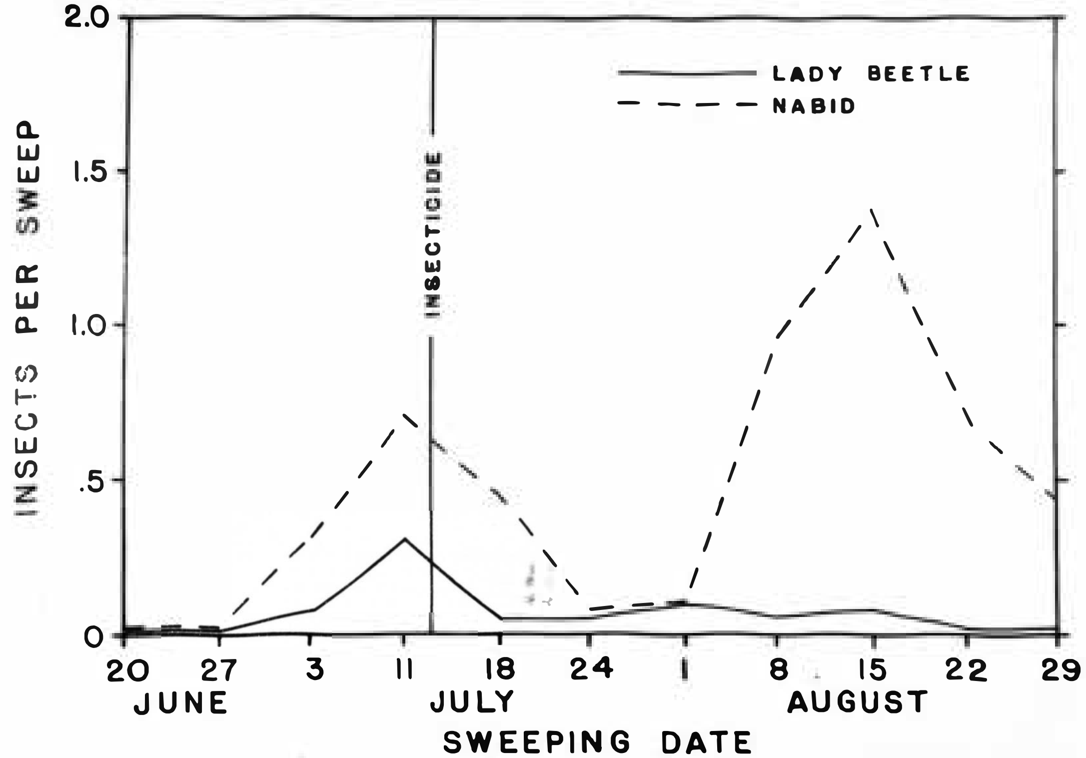

Figure 16. Population levels of the lady beetle and nabid and the effects of the insecticidal application applied July 13, 1957.

Alfalfa seed yields at different distances from the honey bee colonies produced variable results (figure 17). An unusual rapid increase in honey production occurred at the time the honey bees were to be placed on the field. This rapid increase was due to a late spring caused by moisture and cool temperatures followed by a warmer dry period. During this warm period flowers bloomed causing rapid increases in honey production, consequently, causing a tie-up of bees and equipment. Therefore, only 12 colonies of bees were placed in the alfalfa field. This number of colonies was far below the number (60) which were to be used. The colonies were put on the field when the alfalfa was approximately 3/4 in bloom. This factor also affected the seed yield and pollination aspect.

The general survey of other food sources, other apiaries and water (figure 1) showed conditions which undoubtedly influenced the seed yield of this field. An ample supply of water was present for the bees as indicated. Two factors affecting the seed yield in this area were: (1) the bees from the 12 colonies could have been lured to other food sources in the area surveyed, or (2) other bees in the area could have been working the test field.

Alfalfa stem counts (figure 18) taken at the time of harvesting compared with seed yields showed that the highest seed producing area (figure 17) occurred in the locations with less densely populated alfalfa. The highest individual seed yielding area was 1000 feet south of the colonies (figure 17). This location was the most sparsely populated stem area of alfalfa. Lodging occurred at stations East, 1200 feet; and West, 200, 400, 600, and 800 feet which were high stem count and low seed

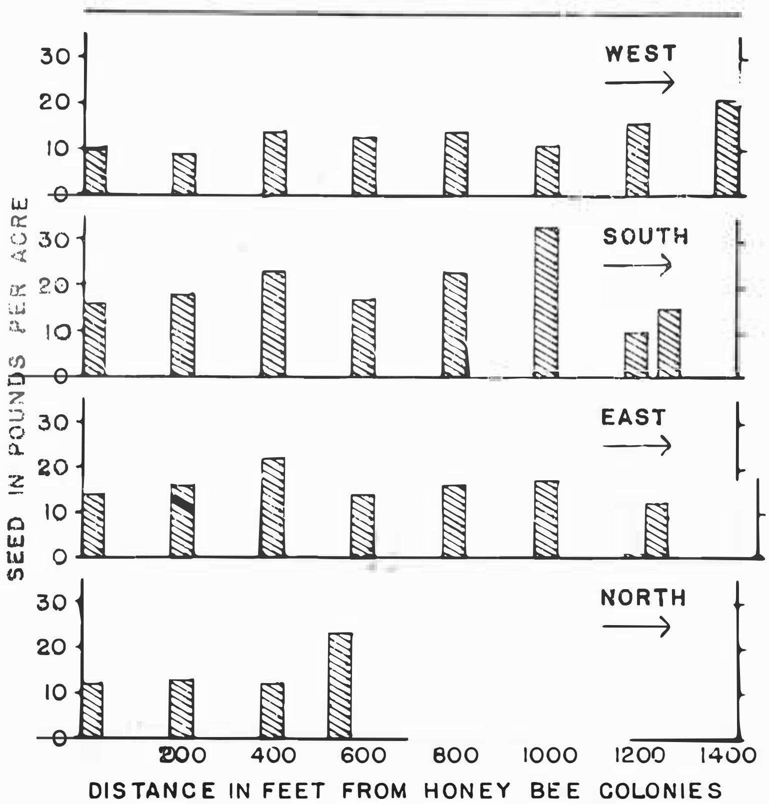

Figure 17. Alfalfa seed in pounds per acre produced at 200 foot intervals from the honey bee colonies.

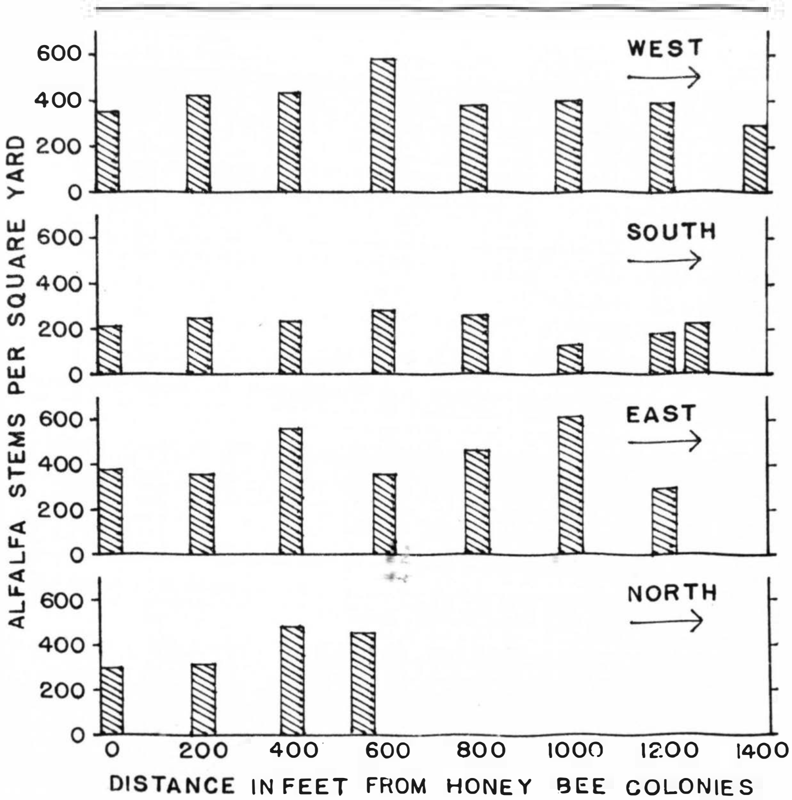

Figure 18. Alfalfa plant density at 200 foot intervals from the honey bee colonies.

producing areas.

Soil samples (table 2) obtained at the time of harvesting indicated no serious deficiencies causing it to be undesirable for alfalfa seed production. The only concern could have been the low phosphorous level which has not been shown to cause any effects on seed yield.

The seed yield from the caged area (table 3) was extremely low and the number of stems per square yard was about average. Therefore, this evidence indicates pollinating insects are beneficial in alfalfa seed production. The caged area was not replicated in these tests.

A very high percentage of nectar collecting bees were found carrying alfalfa pollen on the proboscis fossae. Percentages of the 13 collections taken ranged from 83 per cent to 100 per cent. Nine of the collections were above 90 per cent (table 4). The 83 per cent reading occurred when the alfalfa field was in early bloom. This low percentage could have been the result of bees introducing themselves to alfalfa for the first time. Care was taken in selecting only nectar collecting honey bees for this observation. August 6 was a very windy day with gusts from 20 to 30 miles per hour. Bees collected this day contained pollen on all parts of the body. It was noted that these bees lit on about every third blossom due to the windy condition. As a result, each bee brushed up against many blossoms and came in contact with the pollen. Several instances were noted on other days as to the presence of alfalfa pollen on the exterior surface of the body. A statistical analysis between the four fields (table 4) showed no differences occurred in the collections (table 5). A statistical analysis dividing the four fields into a southern area (Brookings) and a northern area (Project, Clark, and Bristol)

Table 2. Test results of soil samples from the top six inches of soil in the alfalfa field on the Charles Blackman farm.

Station Number	#1A NO_2	Avail. P. #1A	Avail. K. #1A	pH*	Salinity**	O.M.	Texture
Cage	0	3.1	800+	7.3	51	Medium	SiLo
N-0	5	15.3	800+	7.1	50	"	Lo
N-2	2	3.9	774	7.1	47	"	"
N-4	2	5.3	654	7.5	40	"	"
N-5+50	2	5.0	646	7.4	43	"	"
E-0	2	5.6	762	7.4	48	"	SiLo
E-2	5	7.0	800+	6.9	52	"	"
E-4	5	10.2	800+	7.2	56	"	"
E-6	5	5.0	800+	6.7	54	"	"
E-8	5	3.9	800+	6.9	56	"	"
E-10	5	4.6	800+	7.4	56	"	"
E-12	10	14.3	800+	7.6	57	"	Lo
S-0	2	7.6	800+	7.2	50	"	"
S-2	5	6.2	800+	7.0	54	"	"
S-4	2	4.8	720	6.9	54	"	SiLo
S-6	2	5.6	800+	7.0	51	"	"
S-8	2	5.6	800+	6.8	46	"	Lo
S-10	2	7.8	800+	6.2	52	"	"
S-12	2	11.3	800+	6.5	45	"	"
S-12+70	2	11.9	800+	6.9	46	"	"
W-0	2	4.3	620	7.6	51	"	"
W-2	2	4.9	800+	7.6	43	"	"
W-4	2	4.9	710	7.5	43	"	"
W-6	0	5.0	368	7.6	30	"	LoSa
W-8	2	4.9	352	7.6	40	"	SaLo
W-10	5	4.3	546	6.8	58	"	SiLo
W-12	5	5.9	800+	6.8	51	"	"
W-14	5	9.4	800+	7.4	48	"	Lo

*Tested by paste pH in saturated soil.
**Tested by saturation per cent.

Table 3. Individual alfalfa seed weights of the cage area and the five yard-square samples at each station.

Station Number	Grams/Square Yard
Cage	.293
N-0-1	1.348
N-0-2	1.585
N-0-3	1.285
N-0-4	.771
N-0-5	.524
N-2-1	2.292
N-2-2	1.546
N-2-3	.871
N-2-4	.579
N-2-5	.775
N-4-1	1.329
N-4-2	.992
N-4-3	.892
N-4-4	1.268
N-4-5	1.293
N-5+50-1	3.256
N-5+50-2	.985
N-5+50-3	2.173
N-5+50-4	1.944
N-5+50-5	2.242
E-0-1	1.751
E-0-2	1.434
E-0-3	1.253
E-0-4	.846
E-0-5	1.284
E-2-1	1.805
E-2-2	2.390
E-2-3	1.935
E-2-4	.649
E-2-5	.592
E-4-1	1.897
E-4-2	1.686
E-4-3	2.131
E-4-4	1.289
E-4-5	3.490
E-6-1	.790
E-6-2	1.522
E-6-3	1.532
E-6-4	.688
E-6-5	2.111
E-8-1	.833
E-8-2	1.811
E-8-3	1.799
E-8-4	1.314
E-8-5	1.620
E-10-1	.911
E-10-2	1.208
E-10-3	3.440
E-10-4	1.131
E-10-5	1.092
E-12-1	1.503
E-12-2	.427
E-12-3	1.404
E-12-4	.721
E-12-5	1.405
S-0-1	1.421
S-0-2	1.952
S-0-3	1.379
S-0-4	.803
S-0-5	1.827
S-2-1	1.401
S-2-2	1.879
S-2-3	1.204
S-2-4	2.151
S-2-5	1.808
S-4-1	1.424
S-4-2	2.289
S-4-3	2.546
S-4-4	2.001
S-4-5	2.582

Table 3. Continued.

Station Number	Grams/Square Yard
S-6-1	1.884
S-6-2	1.083
S-6-3	1.874
S-6-4	1.367
S-6-5	1.906
S-8-1	1.867
S-8-2	1.936
S-8-3	2.230
S-8-4	2.289
S-8-5	2.676
S-10-1	3.401
S-10-2	2.316
S-10-3	4.324
S-10-4	2.688
S-10-5	2.701
S-10-1	1.136
S-10-2	.764
S-10-3	1.186
S-10-4	.568
S-10-5	1.115
S-12+70-1	1.027
S-12+70-2	1.453
S-12+70-3	1.429
S-12+70-4	1.607
S-12+70-5	1.414
W-0-1	1.230
W-0-2	1.266
W-0-3	.518
W-0-4	.844
W-0-5	.920
W-2-1	1.254
W-2-2	1.157
W-2-3	.712
W-2-4	.887
W-2-5	.456
W-4-1	.945
W-4-2	1.166
W-4-3	1.900
W-4-4	1.553
W-4-5	.916
W-6-1	1.568
W-6-2	1.197
W-6-3	.937
W-6-4	1.629
W-6-5	.992
W-8-1	1.527
W-8-2	1.301
W-8-3	.637
W-8-4	1.791
W-8-5	1.270
W-10-1	.900
W-10-2	1.103
W-10-3	1.284
W-10-4	.547
W-10-5	1.392
W-12-1	1.793
W-12-2	1.817
W-12-3	1.597
W-12-4	1.337
W-12-5	.985
W-14-1	1.521
W-14-2	2.036
W-14-3	1.636
W-14-4	1.529
W-14-5	3.175

Table 4. Results of the nectar collecting honey bees on alfalfa showing the percentage with pollen on the proboscis fossae.

Collection Points	Date of Collections	Number Bees Collected	Number Bees With Pollen	Percentage Carrying Pollen
Brookings	July 29	52	43	83
"	August 6	60	60	100
"	August 9	55	53	96
"	August 13	51	47	92
"	August 15	55	53	96
"	August 20	55	54	98
"	August 23	51	45	88
Project	August 8	38	34	89
"	August 15	50	47	94
"	August 22	52	45	87
Clark	August 22	57	52	91
Bristol	August 8	132	129	98
"	August 22	64	63	98

Table 5. Analysis of variance of nectar collecting honey bees between the four fields.

Source of Variation	Sum Squares	Degrees of Freedom	Mean Squares	F.
Between fields	81.49	3	27.16	1.004 NS
Within fields	243.43	9	27.04	
Total	324.92	12		

NS-Not significant at 5 per cent probability also showed no differences occurred among the collections (table 6).

Table 6. Analysis of variance of nectar collecting honey bees between the southern and northern area.

Source of Variation	Sum Squares	Degrees of Freedom	Mean Squares	F.
Between areas	.66	1	.66	.022 NS
Within areas	324.26	11	29.48	
Total	324.92	12		

NS-Not significant at 5 per cent probability

SUMMARY AND CONCLUSIONS

The use of honey bees for alfalfa seed production on the Charles Blackman farm, Clark County, South Dakota produced the following results:

1. The effects of direction and distance from honey bee colonies on alfalfa seed yields were felt to be inadequately determined because of adverse conditions during this project. Therefore, no conclusions could be made on this portion of the experiment.
2. Greatest seed yields occurred in areas of less densely populated alfalfa. Heavily populated and lodged areas of alfalfa produced low seed yields.
3. The caged area, being void of insects, produced a very low seed yield as compared to areas susceptible to insects. This would indicate pollinating insects are necessary for good seed production.
4. Nectar collecting honey bees working alfalfa do collect and transport alfalfa pollen under South Dakota conditions. Results revealed over 83 per cent of these bees were carrying alfalfa pollen on the proboscis fossae. It seems logical to assume that this pollen is distributed in some degree to alfalfa blossoms visited later for nectar. Future investigations may show this method of pollen transportation to be the answer to the honey bee's ability to increase alfalfa seed yields even though it trips relatively few blossoms.

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APPENDIX

Table 7. Number of insects per sweep taken from the alfalfa field on the Charles Blackman farm.

Insect	Average Number of Insects Per Sweep										
	June		July				August				
	20	27	3	11	18	24	1	8	15	22	29
Alfalfa Plant Bug	.13	.19	.22	.26	.01	-	.14	1.83	2.12	1.68	1.39
Blister Beetle	.23	.03	.25	.18	.01	.01	.01	.11	.11	.04	.02
Grasshopper	.19	.36	.52	.67	.03	.06	.03	.55	.17	.14	.19
Lady Beetle	-	.01	.08	.32	.04	.06	.10	.06	.08	.02	.05
Leaf Hopper	.44	.92	1.25	.37	.54	.07	.01	.25	.55	.33	-
Lygus Bug	.43	.70	1.55	2.35	.16	.06	.17	.97	1.38	1.16	.36
Nabid	.01	.01	.31	.69	.47	.09	.11	.97	1.39	.73	.43
Pea Aphid	1.21	5.05	43.64	167.18	.22	.17	.95	.20	.70	1.67	.13
Potato Leaf Hopper	-	-	-	.08	.16	.10	.09	.03	.01	.02	-
Rapid Plant Bug	-	.02	.03	.03	-	-	-	.01	.06	.14	.01
S. Scissifrons	.28	.07	.06	.18	.02	.03	-	.99	.12	.08	.01

Table 8. Stations, seed yield and stem count in the alfalfa field on the Charles Blackman farm.

Station Number	Total Grams Per Five Square Yards	Average Grams Per Square Yard	Pounds Per Acre*	Stems Per Square Yard
Cage	.293	.293	3.126	260
N-0	5.513	1.103	11.769	296
N-2	6.166	1.233	13.156	312
N-4	5.774	1.155	12.324	482
N-5+50	10.600	2.120	22.620	454
E-0	6.568	1.314	14.020	382
E-2	7.371	1.474	15.728	368
E-4	10.493	2.099	22.396	560
E-6	6.643	1.329	14.180	352
E-8	7.377	1.475	15.738	457
E-10	7.782	1.556	16.603	613
E-12	5.460	1.092	11.652	295
S-0	7.382	1.476	15.749	210
S-2	8.443	1.689	18.022	245
S-4	10.842	2.168	23.133	232
S-6	8.114	1.623	17.317	286
S-8	10.998	2.200	23.474	260
S-10	15.430	3.086	32.927	133
S-12	4.769	.954	10.179	181
S-12+70	6.935	1.387	14.799	221
W-0	4.778	.956	10.201	346
W-2	4.266	.853	9.102	418
W-4	6.480	1.296	13.828	430
W-6	6.323	1.265	13.497	571
W-8	6.526	1.305	13.924	385
W-10	5.226	1.045	11.150	402
W-12	7.529	1.506	16.069	390
W-14	9.897	1.979	21.116	296

*Conversion factor from grams per square yard to pounds per acre = 10.67